COASTAL ECOSYSTEM SCIENCE LESSON PLAN

Alien Invasion!

Theme
Invasive Species

Links to Overview Essays and Resources Needed for Student Research
http://www.nccos.noaa.gov/stressors/invasives/science.html
http://oceanservice.noaa.gov/topics/coasts/ecoscience/

Subject Area
Life Science

Grade Level
9-12

Focus Question
What are invasive species, why are they a problem, and what can be done about them?

Learning Objectives
- Students will be able to define, compare, and contrast invasive species, alien species, and native species.
- Students will be able to describe at least three problems that may be associated with invasive species.
- Students will be able to describe at least three invasive species, explain how they came to be invasive, and discuss what can be done about them.

Materials Needed
- (optional) Computers with internet access; if students do not have access to the internet, download copies of materials cited under "Learning Procedure" and provide copies of these materials to each student or student group.

Audio/Visual Materials Needed
None

Teaching Time

One or two 45-minute class periods, plus time for student research

Seating Arrangement

Classroom style or groups of two students

Maximum Number of Students

45

Key Words

Invasive species
Alien species
Native species
Vector

Background Information

What is an "invasive species?" — A species in an ecosystem is considered to be invasive when it is not native (alien) to the ecosystem and causes economic and/or environmental harm, or poses a threat to human health. All types of living organisms (plants, animals, bacteria, etc.) can be invasive.

How do invasive species invade in the first place? — Human activities are the most common means through which alien species are introduced into ecosystems. Even when these species survive, they are not considered invasive unless they cause the type of harm described above. But if an ecosystem does not contain species that are able to control the population of an introduced species, the alien species may become invasive as it reproduces and disperses.

Some alien species have been deliberately introduced through expanded global trade, harvesting exotic marine species for the aquarium industry, and use of non-native species in agriculture and pest control. Kudzu was originally imported from the Orient as an ornamental plant and was widely used for erosion control. But in the absence of natural controls, the alien plant became invasive as it spread and overgrew native plants. The Gypsy moth was imported in the late 1860's from France in an attempt to establish a silk industry in Massachusetts. The moths escaped and are now a major threat to U.S. forests. Other introductions are accidental. Fruit smugglers have inadvertently caused many outbreaks of the Mediterranean Fruit Fly (medfly), one of the world's most destructive fruit pests. Medfly larvae are able to develop and feed on fruits of many economically important trees and vegetables, including citrus, peach, pear, and apple. Larvae feed on the fruit pulp and eventually reduce the entire fruit to a juicy inedible mess. The zebra mussel is a well-known example of an invasive species introduced in the ballast water of ocean-going ships. Infestations of these mussels can clog water treatment and intake systems, interfering with many industrial activities, docks and boat engines. Wooden shipping containers may contain insects and plant diseases and were probably responsible for introduction of the wood-boring Asian Long-horned Beetle into the United States. Larvae of these beetles bore large tunnels that disrupt the flow of water and food materials within the tree. Eventually the tree literally falls apart and dies.

There is a similar variety of pathways through which invasive species are spread from the site at which they are introduced. Natural pathways include water, wind, and other species. Wind is particularly significant in dispersing many plant diseases. Biological pathways are called vectors. For example, birds that eat the fruit of alien plants may carry the seeds over long distances before expelling the seeds in their feces. Similarly, cattle are vectors that disperse Tropical Soda Apple seeds. The weed spreads rapidly when cattle are sold from an infested region and transported to uninfested areas.

Human beings may be vectors as well. Female Gypsy moths, for example, lay their egg masses on cars, recreational vehicles, and other surfaces. If humans carry an egg mass into an uninfested area, a new infestation is started. Since the moths cannot fly, human activity can greatly increase the rate at which the moths disperse. In fact, it is estimated that the Gypsy moth invades an additional 15,600 square miles each year (three times the area of Connecticut). Boats and boat trailers have played a large part in the rapid spread of Giant Salvina, a water fern from southeastern Brazil that crowds out native water plants, depletes dissolved oxygen in the water, interferes with migrating birds, and clogs water intakes of irrigation system and electrical generators.

So, some new species come to visit; what's the big deal? — Invasive species can damage native species, change the native community structure, and can create serious economic problems. Invasive species threaten nearly half of the species currently protected under the Endangered Species Act. A single outbreak of medfly may cost millions of dollars to eradicate. Approximately 50,000 exotic species already are known to exist in the U.S., and this number is increasing. The costs of environmental damage, economic losses, and control measures for invasive species average $138 billion per year, more than all other natural disasters combined.

What can be done about invasive species? — Prevention, early detection and eradication are key strategies for dealing with invasive species. If there had been a response when the Gypsy moth escape was first reported, the moth might never have become established.

Port inspectors from the U.S. Department of Agriculture and Department of the Interior are responsible for detecting illegal importations of fruit, vegetables, animal products, fish and wildlife. Public education is also a vital part of prevention, and there are a variety of things that individuals can do to prevent inadvertent introductions. Homeowners can avoid purchasing invasive landscaping plants, and can replace invasive garden plants with non-invasive alternatives. Aquarium keepers can avoid introducing exotic fish and other aquatic species into local water bodies. Owners of exotic pets should remember that these pets may become invasive if they escape or are released. Boaters should clean boat and trailers thoroughly before transporting them to a different body of water. Hikers should clean their boots to get rid of weed seeds and pathogens which may have become attached.

The National Centers for Coastal Ocean Science of the National Ocean Service is developing a pilot early warning system that is intended to provide a way to detect aquatic invasive species before they become well-established. This project is initially focused on Hawaii's marine and estuarine coastal areas. An internet-accessible database of native coastal species will help marina operators, boaters, and other cooperating groups recognize unusual species that they may encounter. These encounters will be reported to resource managers for further investigation.

Eradication may involve:

- Mechanical Controls;
- Cultural Controls;
- Biological Controls; or
- Chemical Controls

Mechanical controls include the use of heavy equipment, power and hand tools, draught animals, prescribed fire, explosives, or manual removal. Cultural controls involve educating people and encouraging actions that minimize the spread of invasive species. Biological controls include the use of natural enemies such as insects or pathogens that attack invasive species and limit their growth or reproduction. Another biological control strategy for invasive plants is to encourage succession (the normal process in which dominant plant species change as an ecosystem matures), so that development of native evergreen conifers and/or hardwoods shades plants underneath and suppresses or eliminates shade-intolerant exotic species. Chemical controls include manipulation of water or soil chemistry to favor growth of native species, as well as pesticides and herbicides. The latter chemicals are generally only used as a last resort since they often affect desirable species as well as invasive ones.

The purpose of this activity is to introduce students to typical causes and impacts of invasive species, as well as sources of information on these species and appropriate remedial actions.

Learning Procedure

1.

Briefly review the broad concept of invasive species. Be sure students understand the conditions under which an organism typically becomes invasive and are able to differentiate between native species (species that are a natural part of an ecosystem), alien species (species that are not native), and invasive species (alien species that are harmful to native species or humans).

2.

Tell students that they are to prepare a written case study on an invasive aquatic species. Their reports should include the native location of the species, how it was introduced to an ecosystem, where it became invasive, what impacts are associated with the invasive species, and what control measures are possible. Assign one of the following species to each student or student group:

Protista
Whirling Disease (*Myxobolus cerebralis*)

Algae
Mediterranean Clone of Caulerpa (*Caulerpa taxifolia*)

Seed Plants
Brazilian Waterweed (*Egeria densa*)
Common Reed (*Phragmites australis*)
Eurasian Water-milfoil (*Myriophyllum spicatum*)
Giant Hogweed (*Heracleum mantegazzianum*)
Giant Reed (*Arundo donax*)
Giant Salvinia (*Salvinia molesta*)
Hydrilla (*Hydrilla verticillata*)
Melaleuca (*Melaleuca quinquenervia*)
Purple Loosestrife (*Lythrum salicaria*)
Water Chestnut (*Trapa natans*)
Water Hyacinth (*Eichhornia crassipes*)

Invertebrates
European Green Crab (*Carcinus maenas*)
Zebra Mussel (*Dreissena polymorpha*)

Fishes
Alewife (*Alosa pseudoharengus*)
Asian Swamp Eel (*Monopterus albus*)
Eurasian Ruffe (*Gymnocephalus cernuus*)
Lionfish (*Pterois volitans*)
Northern Snakehead (*Channa argus*)
Sea Lamprey (*Petromyzon marinus*)

Amphibians
North American Bullfrog (*Rana catesbeiana*)

Mammals
Nutria (*Myocastor coypus*)

3.
Have students present their research results orally, and lead a discussion to summarize means of introduction, typical environmental, economic, and/or social impacts, and potential control measures. The following points should be included in these presentations:

Whirling Disease (*Myxobolus cerebralis*)

Native Location and Introduction – Endemic to salmonid fishes (e.g., salmon, trout) in Europe; inadvertently introduced to the eastern U.S. in 1955 via shipments of frozen trout containing spores of *M. cerebralis.*

Impacts – Whirling disease is a potentially fatal condition affecting trout that is caused by a microscopic amoeba. This parasite has a two-host life cycle involving trout and a common bottom-dwelling tubifex worm. When an infected trout dies, large numbers of spores are released. When the spores are eaten by the tubifex worm, they incubate within the worm's gut and rapidly multiply. When released from the worm, the spores can attach to the bodies of vulnerable fish species. Fishes may also become infected by eating infected worms. The parasite attacks the soft cartilage in young fishes, causing nerve damage, skeletal deformities, and possibly death. Nerve damage and skeletal deformities cause some infected fish to exhibit a "whirling" motion when swimming. Once a fish reaches three to four inches in length, cartilage forms into bone and the fish is no longer susceptible to effects from whirling disease. These fish, however, are still carriers of the parasite. The spore stage of the parasite is extremely durable and is easily spread. Fish transfers have probably been responsible for dispersing whirling disease to many of the states in which it has been detected. Whirling disease has been linked to major declines in several Rocky Mountain fisheries.

Control – Control measures emphasize inspection of fish hatcheries to detect the disease. Because mud may contain tubifex worms, public education programs remind boaters to wash mud from fishing equipment and to drain water from boats and coolers before moving from one water body to another. Fishermen are cautioned to avoid disposing of fish entrails in natural water bodies; and to avoid transporting fish and aquatic plants from one body of water to another.

The Mediterranean Clone of Caulerpa (*Caulerpa taxifolia*)

Native Location and Introduction – Believed to be a hearty hybrid inadvertently produced at the Stuttgart Aquarium in Germany and subsequently leaked into the environment from another marine institution; commonly used in saltwater aquaria, and has only recently been banned from sale in the U.S.

Impacts – This alga contains a toxin that is lethal to some species and may interfere with the eggs of some marine mammals. Plants form dense mats that displace invertebrates, fish, and native algae.

Control – Many control methods have been tried including diver-operated pumps, poisons, smothering with a cover that lets in no light, and using underwater welders to boil the plant.

Brazilian Waterweed (*Egeria densa*)

Native Location and Introduction – Native to Brazil; introduced to North America for aquarium use.

Impacts – Forms dense mats that suppress native aquatic plants, interfere with recreational water uses, and provide poor habitat for fish.

Control – Brazilian waterweed is difficult to control and has few natural predators. Aquatic herbicides and grass carp are effective in some circumstances. Harvesting is not a good option as it allows small plant fragments to spread to new areas.

Common Reed (*Phragmites australis*)

Native Location and Introduction – Native to North America; unusual outbreaks may be due to the introduction of a more genetically aggressive strain.

Impacts – *P. australis* can easily take over an area when there is environmental stress, such as restricted water flow or pollution. When the reed becomes invasive, it reduces biodiversity in wetlands, displaces other native species, alters habitat of birds and fish, and creates a fire hazard when large amount of reeds die.

Control – The easiest control method is to eliminate restrictive flows. Cutting or mowing can help, but if done at the wrong time can stimulate growth and make denser stands. Burning works if its roots are burned, but otherwise can also stimulate growth. Covering with plastic after mowing is effective because of high temperatures generated under the plastic, but is labor intensive. Herbicides are effective, but affect desirable species as well. Aggressive replanting of other native species is usually needed in conjunction with techniques that kill Phragmites.

Eurasian Water-milfoil (*Myriophyllum spicatum*)

Native Location and Introduction – Accidentally introduced from Eurasia in the 1940s, possibly from an aquarium or boat.

Impacts – Because this species is tolerant of many water pollutants, it tends to invade disturbed areas where native plants are less able to re-grow. The plant forms large, floating mats that prevent light penetration for native plants and impede water traffic.

Control – The best option is to use harvesting equipment or hand tools to mechanically remove plants, since other options such as manipulation of water level, reducing light penetration with dyes or floating plants, and chemical control are apt to impact native aquatic plants as well.

Giant Hogweed (*Heracleum mantegazzianum*)

Native Location and Introduction – Native to the Caucasus mountains and southwestern Asia; introduced in Europe, the United Kingdom, Canada, and the United States as a garden curiosity.

Impacts – These plants are tenacious and invasive by nature and readily escape from gardens. They grow along streams and form dense canopies, outcompeting native species and causing increased soil erosion. The plants exude a clear watery sap which sensitizes human skin to ultraviolet radiation, resulting in severe burns, blistering and painful dermatitis that may develop into purplish or blackened scars.

Control – Herbicides are the most effective control method. Plants may be dug out, but the process can be difficult and unpleasant. Cattle and pigs have been suggested as possible biocontrol agents since both eat giant hogweed without apparent harm.

The Giant Reed (*Arundo donax*)

Native Location and Introduction – Native to India; introduced to Europe in ancient times; imported to North America during the early colonial period and used for roofing material, fodder, and musical instruments; now commonly used in gardens and for erosion control.

Impacts – This species tends to displace native plants and associated wildlife species, reduces habitat quality for aquatic wildlife, interferes with levee maintenance and wildlife habitat management, may reduce groundwater availability by transpiring large amounts of water, alters waterways by retaining sediments and constricting flows, and creates fire hazards.

Control – Mechanical removal is effective if stems and roots are removed or burned on-site. In most situations, chemical methods are needed in combination with mechanical removal to achieve eradication.

Giant Salvinia (*Salvinia molesta*)

Native Location and Introduction – Native to South America; deliberately introduced as an ornamental aquatic plant; spread by boats, fishing gear, dumping of aquaria, and other unintentional means.

Impacts – Giant salvinia grows rapidly and spreads across water surfaces, forming dense mats that cut off light to native plants, reduce oxygen content and degrade water quality for fish and other aquatic organisms.

Control – Plants can be removed by raking, but will reestablish from remaining fragments. Grass carp will consume salvinia, but are usually not effective for total control. Broad spectrum, systemic herbicides are effective but may also affect desirable plant species. Biological control may be possible with the weevil Cyrtobagous salviniae.

Hydrilla (*Hydrilla verticillata*)

Native Location and Introduction – Native to Central Africa; deliberately imported for the aquarium trade.

Impacts – Out-competes native submerged aquatic vegetation and quickly fills ponds or lakes to the extent that it interferes with boating, fishing, swimming and other recreational uses. These plants provide good habitat for fish and shellfish, as well as some water quality benefits.

Control – Physical, chemical and biological controls have all been used, but are rarely entirely successful. Mechanical aquatic weed harvesters can open boating lanes, but plant fragments subsequently spread the vegetation. Grass carp have been used and may control growth of *Hydrilla* in some cases.

Melaleuca (*Melaleuca quinquenervia*)

Native Location and Introduction – Native to Australia; deliberately introduced in Florida as an ornamental plant.

Impacts – This species has high rates of transpiration (transfer of water from leaves to the atmosphere) which make the species useful for controlling floods and for maintaining water levels. Melaleuca is also used for erosion control because of its fast growth and ability to quickly invade disturbed sites. Extracts from the plant are used in a variety of commercial products including antiseptics, beverages, shampoos, perfumes, honey, candy, ice cream, and germicides. This species is a fast-growing evergreen that typically grow between 50 and 70 feet high, but may reach heights of 90 feet. It quickly crowds out other species and prevents growth of understory vegetation, and consequently tends to establish monocultures (that is, there are no other plant species co-existing with Melaleuca). Melaleuca provides poor habitats for native species and may radically alter wetland ecosystems.

Control – Melaleuca tolerates a wide range of environmental disturbances, but cannot tolerate freezing. Many control methods which are effective against other species actually increase Melaleuca propagation. Herbicides, burning, and other disturbances cause seeds to be released. Adults and larvae of the Melaleuca snout beetle (*Oxyops vitiosa*) feed on the leaves and shoots of Melaleuca. This damage may slow the spread of the trees and weaken them so that they are more susceptible to other control measures.

Purple Loosestrife (*Lythrum salicaria*)

Native Location and Introduction – Native to Eurasia; accidentally introduced in the early nineteenth century as a ship ballast contaminant, and deliberately as a medicinal herb for treating diarrhea, dysentery, and ulcers.

Impacts – Loosestrife grows very aggressively, producing large stands that displace native plant species and eliminate natural foods and cover essential to wildfowl and many other wetland inhabitants. These stands can also impede flows in irrigation systems.

Control – No native herbivores or pathogens in North America are known to suppress purple loosestrife. Current controls are mechanical cutting and/or herbicides. There has been some success with biological control using insects.

Water Chestnut (*Trapa natans*)

Native Location and Introduction – Native to Asia; first recorded in North America near Concord, Massachusetts in 1859

Impacts – This species grows rapidly in slow moving shallow water with mud bottoms, displacing native aquatic plants. Rapid sedimentation may occur due to trapping of silt. Light penetration and oxygen are reduced, creating a hazard to fish and other aquatic species. Water Chestnut is a poor source of food for wild fowl. Impacts on recreation result from reduction in available fishing area and hazards to boating motors. Infestations can make boating, fishing and swimming difficult or impossible.

Control – Hand removal and mechanical harvesting are most effective control methods but must be applied for at least five years due to the long dormant period of dispersed seeds.

Water Hyacinth (*Eichhornia crassipes*)

Native Location and Introduction – Native to South America; introduced to the U.S. as an ornamental plant in the 1880's.

Impacts – Water hyacinth grows profusely, forming dense mats that can spread across the surface of an entire water body. Infestations destroy native wetlands and kill native fish and other wildlife. These plants cause high evaporation rates and loss of water, degrading water quality. The large mats impede transport of irrigation and drainage water, hinder navigation, decrease production of species used by humans for food, and constrain recreational opportunities. The risk of entanglement in heavy growth poses a health risk to humans and livestock.

Control – Water hyacinth is difficult (if not impossible) to destroy. Fire and explosives have been tried, but plants reproduce rapidly from small fragments. Biological controls are most effective; two species of weevils, a moth, and two types of fungi attack various parts of the plants and have proven to be successful controls. Unfortunately, these are also exotic species, and in most cases their potential impact on native ecosystems is not entirely known. Chinese grass carp (*Ctenopharyngo idella*), *Tilapia melanopleura*, *T. mossambica*, and manatees are also useful controls.

European Green Crab (*Carcinus maenas*)

Native Location and Introduction – Native to the North and Baltic Seas; introduced to the U.S. over 150 years ago, probably via dry ballast and heavily fouled outer hulls of wooden ships coming from Europe.

Impacts – These crabs feed on a variety of organisms, including clams, oysters, mussels, marine worms and small crustaceans, and consequently are a serious potential competitor with native fish and bird species. At the turn of the century, European green crabs almost destroyed the soft clam industry of Maine and surrounding waterways; this is at least partially responsible for the decline of scallop populations on Martha's Vineyard. In California, it has caused the loss of as much as 50 percent of Manila clam stocks and declines in other crab populations.

Control – It is probably impractical to completely eliminate the species. Bounty programs that pay rewards for captured green crabs have helped to control populations on the East Coast. Biological control may be possible with the Sacculina carcini barnacle, a natural predator from Europe which pierces the crab's exoskeleton and causes sterility. Obviously, the potential impact of these barnacles on native species is a serious concern that needs to be addressed before considering introduction as a biological control.

Zebra Mussels (*Dreissena polymorpha*)

Native Location and Introduction – Native to the Caspian Sea and Eastern Europe; introduced to the Great Lakes in 1985 by ocean-going ships carrying contaminated ballast water.

Impacts – This species reproduces rapidly, and a single zebra mussel may filter as much as one liter of water per day, habits that allow this species to successfully compete with native mussels for food and space. Infestations of zebra mussels clog water treatment and intake systems, interfering with many industrial activities, as well as docks and boat engines. The sharp shells of the mussels also degrade the quality of beaches for recreation.

Control – The primary control method is limiting further dispersal by carefully cleaning boats and other recreational equipment. No chemical controls have been identified that will not also damage other aquatic life. Zebra mussels are sensitive to high temperatures and hot water outflows may help control their populations. Some native species are predatory on zebra mussels, but are not effective controls.

Alewife (*Alosa pseudoharengus*)

Native Location and Introduction – Native to the U.S. East Coast, from Newfoundland to the Carolinas; was originally entirely anadromous (a species that breeds in freshwater but returns to the ocean to complete its life cycle); entered the Great Lakes in the late 19th century, possibly introduced when Lake Ontario was stocked with American shad in the 1880s, or possibly via the Erie canal when the canal connected the Great Lakes to the Atlantic Ocean; introduction would not have been possible except that Atlantic salmon and lake trout, two significant natural predators for the alewife, were severely over-fished.

Impacts – Great Lakes populations of alewife now complete their entire life cycle in freshwater. These fish feed extensively on zooplankton (microscopic animals that live in the water column), as well as small insect and fish larvae, and consume enough plankton to noticeably increase water clarity. This benefits tourists who want clear water in the lakes, but can also cause large algal blooms because of the drastic reduction in numbers of zooplankton that would normally eat the algae. Alewife provide food for many predators, but have fundamentally altered the Great Lakes ecosystem. Some fish populations in the Great Lakes are nearly 75% alewife. Periodic mass die-offs leave hundreds or thousands of decaying fish on beaches.

Control – Alewife have become so integrated into the Great Lakes ecosystem that attempts to remove this species could potentially do unforeseen damage to many parts of the system. In many cases, alewife actually benefit local economies. Caution is needed, however, to avoid introducing alewife into other systems, since the ability of this species to radically affect biodiversity and native species has been well-demonstrated. Restrictions on transporting and capturing alewife may be helpful in preventing further spread of the species.

Asian Swamp Eel (*Monopterus albus*)

Native Location and Introduction – Native to eastern and southern Asia and possibly Australia; introduced in Hawaii around 1900 as a food fish; introduced into southern Florida and northeastern Georgia in 1990s, probably from an aquarium or fish farm.

Impacts – The eel has no known natural predators in the U.S., and feeds on a variety of water animals. The eel can also breathe air, can travel over land when necessary, and is able to survive heavy freezes and ice cover. The swamp eel is also able to feed in and out of water, and can survive for months without food if necessary. The swamp eel may pose a serious threat to native ecosystems, especially the Florida Everglades where it could cause loss of native species.

Control – No method of control has been established. Conventional fish poisons that interfere with a fish's ability to use oxygen are not effective on eels. Even blasting with dynamite is ineffective since eels do not have a large air bladder that makes a fish susceptible to concussion, and because the eels are able to avoid much of the blast by retreating into their burrows. At present, the only way to catch a swamp eel is by using an electric shock.

The Eurasian Ruffe (*Gymnocephalus cernuus*)

Native Location and Introduction – Native to many parts of Europe and Asia; introduction to North America probably via ballast water.

Impacts – Ruffe are prolific breeders, aggressive feeders, and can tolerate a wide range of ecological and environmental conditions. They are tolerant of pollution that adds nutrients to aquatic systems, and their abundance tends to increase under these conditions. Their diet includes a wide variety of invertebrates and other fishes. This flexible diet may provide a competitive advantage, and ruffe complete with many species of native fishes. This species has limited recreational or economic value.

Control – Control is important in areas such as the Great

Lakes where ruffe have the potential to threaten commercially important species such as herring, whitefish, lake trout, and yellow perch. Effective control methods are limited. Poisons have been suggested, but may have adverse effects on other organisms. Some managers believe that it is too late to eliminate the ruffe, and instead are focussing efforts on limiting further dispersal. The major emphasis of these efforts is to control dispersal via ballast water.

Lionfish (*Pterois volitans*)

Native Location and Introduction – Native to the Indo-Pacific from Australia north to southern Japan and south to Micronesia; probably introduced into southern Florida and/or the coast of the Carolinas in early to mid 1990s, either in ballast water or from aquaria.

Impacts – Lionfish feed on smaller fishes, shrimp, and small crabs. Venomous spines in the dorsal and pectoral fins are used to immobilize prey species, as well as to discourage potential predators. Since lionfish have appeared very recently in waters near the U.S. east coast, their ecological impact is not yet known. If their numbers increase, lionfish may compete with many native species, including economically important species of snapper and grouper. Populations of prey species could be seriously affected as well.

Control – Specific control methods have not been identified.

Northern Snakehead (*Channa argus*)

Native Location and Introduction – Native to China, Russia and Korea; introduced to western Asia, eastern Europe, and the United States as a food fish in Asian markets; releases may have been accidental or deliberate.

Impacts – These fishes compete with native species for food and habitat. Adults feed primarily on other fishes, as well as crustaceans, frogs, small reptiles, and occasionally small birds and mammals. Ecological impacts are not known.

Control – Control measures in the U.S. consist of banning importation of the species, public information asking fishermen to kill any captured snakeheads, and poisoning ponds in which the fish have been found. The latter measure also kills other fish species, so native fish populations have to be restored following elimination of the snakehead.

Sea Lampreys (*Petromyzon marinus*)

Native Location and Introduction – Native to the coastal regions of the North Atlantic Ocean; introduced to the Great Lakes in 1835, probably via canals, dams, flood control structures, and ships carrying ballast water contaminated with lampreys; use of lamprey larvae as sport-fishing bait may also have contributed to spread of the species.

Impacts – Lampreys are agressive predators and feed on a wide variety of fishes by attaching to their prey with a sucker-like mouth. This method of feeding provides yet another means for dispersal. This species has had major impacts on Great Lakes ecosystems. Widespread predation on lake trout (*Salvelinus namaycush*) and other species caused a collapse of commercial fisheries during the 1940s and 1950s in many parts of Lake Huron, Lake Michigan, and Lake Superior. Sea lamprey predation has contributed to the extinction of three endemic fish species, and the loss of large predators was a key factor in the invasion of the Great Lakes by the alewife (*Alosa pseudoharengus*) in the late 1940s. The economic impacts of the sea lamprey invasion resulted in an international program between Canada and the U.S. to control and eradicate the sea lamprey at an annual estimated cost of $10 million.

Control – The joint U.S./Canada program includes control with poisons, construction of barriers in streams to block sea lamprey entry, and an experimental program to reduce spawning success by releasing sterilized male sea lampreys.

North American Bullfrog (*Rana catesbeiana*)

Native Location and Introduction – Native to the central and eastern United States and the southern portions of Ontario and Quebec; now found from Nova Scotia to Central Florida, from the East coast of the U.S. to California and Mexico, as well as in Hawaii, the Caribbean, South America, Europe and Asia; believed to have been accidentally introduced in Colorado and California in the early 1900s during fish stocking operations; other possible modes of introduction include the aquarium trade, deliberate introductions (as a source of frogs legs, aesthetically pleasing wildlife, or agricultural pest controls), or natural migration.

Impacts – Bullfrogs' diet includes snakes, worms, insects, crustaceans, frogs, tadpoles, and other bullfrogs. North

American bullfrogs help control insects and are important for medical research because their skeletal, muscular, digestive, and nervous systems are similar to those of higher animals. They are often hunted or bred for frog legs. Bullfrog tadpoles eat algae, and have a taste that is disagreeable to most fishes, so they often have fewer predators than other frog species. Because North American bullfrogs consume many other species and their tadpoles can have a significant impact on algae, these animals can create major changes in aquatic communities.

Control – Control of this species is important where it threatens native populations. Effective control measures are harvesting adults as a fishery, poisons that affect larvae, and collecting eggs before they hatch.

Nutria (*Myocastor coypus*)

Native Location and Introduction – Native to Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay; introduced into the U.S. for the fur industry; nutria have periodically escaped from ranches in Louisiana; other deliberate introductions have taken place in the Gulf states to control vegetation in lakes and ponds.

Impacts – Nutria eat almost any available terrestrial or aquatic green plant, and are highly prolific. The animals reach sexual maturity as early as four months of age and mate for the entire year. In marsh habitats, nutria compete with muskrat and waterfowl populations for food resources. Nutria also consume commercial crops including rice, sugar cane, and soybeans. They also have been reported to feed on the roots of sea oats, whose ability to colonize open sand and high tolerance of salt spray makes them valuable barriers against coastal erosion (so much so that they are protected by law in some coastal states). These diverse feeding habits have severely damaged wetlands. Consumption of sea oats threatens the stability of sand dunes and decreases the ability of these dunes to protect against coastal erosion. Louisiana nutria carry several diseases, viruses, and parasites, including the nematode *Strongyloides myopotami*, which causes a severe itching rash in people handling the animals. Nutria pose a serious threat to sensitive wetland ecosystems around the Gulf of Mexico, as well as commercial crops in southeast.

Control – Control efforts have emphasized encouraging trapping of nutria for fur and meat, but the success of this method depends upon the demand for fur, and current harvests are far below the level needed to effectively control nutria populations. Trapping for non-commercial purposes has been effective in controlling feral pigs on the island of Hawai'i, and may be an alternative for controlling nutria.

The Bridge Connection

http://www.vims.edu/bridge/ – On the "Site Navigation" menu to the left, click "Ocean Science Topics," then "Biology," then "Exotics" for links to sites and activities dealing with invasive species.

The Me Connection

Although invasive species can cause serious problems for humans and other species, they are only doing what every other organism does: taking advantage of opportunities to survive and perpetuate their species. Have students write a brief essay, describing how the human species might be considered invasive by one or more other species, and what those species might do to deal with these "invaders."

Extensions

Visit *http://www.invasivespecies.org/resources/TimeWarp.html* for an activity that uses invasive species control and eradication techniques to increase participants' abilities to use a group planning and decision-making process, and to compromise within a small group.

Resources

http://www.nccos.noaa.gov/stressors/invasives/science.html – Background information on invasive species from the National Centers for Coastal Ocean Science, National Ocean Service

http://www.nccos.noaa.gov/documents/factsheet_invasivespecies.pdf – Aquatic Invasive Species: Early Detection, Warning, and Information Factsheet

http://invasivespecies.nbii.gov – The Invasive Species Information Node (ISIN) of the National Biological Information

Infrastructure with information on identification, description, management, and control of invasive species; hosted by the Department of the Interior, U.S. Geological Survey

http://www.invasivespecies.gov – A gateway to federal efforts concerning invasive species, including links to species profiles, geographic information, news and events, laws and regulations, resources, management tools, databases, and information on vectors and pathways

http://www.invasivespecies.gov/profiles/main.shtml – Information profiles for many invasive species

http://www.invasivespecies.org/resources/ – website for Invasive Species Educational Resources

http://nature.org/initiatives/invasivespecies/ – Web page for the Nature Conservancy's Invasive Species Initiative

National Science Education Standards

Content Standard C: Life Science

- Interdependence of organisms
- Behavior of organisms

Content Standard F: Science in Personal and Social Perspectives

- Natural resources
- Environmental quality
- Natural and human-induced hazards

Links to AAAS "Oceans Map" (aka benchmarks)

5D/H1 – Ecosystems can be reasonably stable over hundreds or thousands of years. As any population of organisms grows, it is held in check by one or more environmental factors: depletion of food or nesting sites, increased loss to increased numbers of predators, or parasites. If a disaster such as flood or fire occurs, the damaged ecosystem is likely to recover in stages that eventually results in a system similar to the original one.

5D/H3 – Human beings are part of the earth's ecosystems. Human activities can, deliberately or inadvertently, alter the equilibrium in ecosystems.